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Signed A M Brewer.

Dated 3 August 2000

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20APR00 E531380-1 D02884
P01/7700 0.00-0009783.2

Patents Form 1/77

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The Patent Office

Cardiff Road
Newport
South Wales
NP9 1RH

1. Your reference

P22196/PKE/BOU

2. Patent application number
(The Patent Office will fill in this part)

0009783.2

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Milliken Industrials Limited
Wellington Street
Bury
LANCS
BL8 2AY

Patents ADP number *(if you know it)*

605618002

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

"Method of Colouring Material"

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Murgitroyd & Company
373 Scotland Street
Glasgow
G5 8QA

Patents ADP number *(if you know it)*

1198013

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
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Yes

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Continuation sheets of this form	
Description	20
Claim(s)	–
Abstract	–
Drawing(s)	6

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Priority documents	–
Translations of priority documents	–
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	–
Request for preliminary examination and search *(Patents Form 9/77)*	–
Request for substantive examination *(Patents Form 10/77)*	–
Any other documents *(please specify)*	–

11. I/We request the grant of a patent on the basis of this application.

Signature MURGITROYD & COMPANY Date 20.04.2000

12. Name and daytime telephone number of person to contact in the United Kingdom Beverley Ouzman 0141 3078400

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METHOD OF COLOURING MATERIAL

The present invention relates to a new method of colouring material, and especially to a new method of dyeing woven or not woven material which provides the material with an high visibility colour; to the dyed material thus obtained and to the use of such material in the manufacture of products to be used for example in sports and especially in the covering of tennis balls.

Traditionally, tennis balls were covered with a white woollen felt. Several decades ago yellow felt was introduced for use on match quality balls and from the early 1970's balls covered with yellow felt became increasingly popular. Today, the vast majority of tennis balls are covered with yellow felt. Rule 3 of the International Tennis Federation Rules of Tennis states "The ball shall have a uniform outer surface consisting of a fabric cover and shall be white or yellow in colour..."

The felt used on tennis balls was previously made from wool. Increased wear properties are obtained by including a proportion of synthetic fibre in the felt, and nowadays such felt is usually made of a mixture of wool and nylon fibres. The proportions of

wool and synthetic used to produce the felt can vary, but typically a ratio of 40:60 to 60:40 can be used (by weight of weft yarn). It is desirable that the side of the felt termed the "back" (which is the side which will be stuck to the ball) is made of a material which provides good adhesion when it is glued on the internal rubber sphere of the ball. Usually the backing is formed by using 100% cotton warp yarns, but alternatives such as polyester and nylon could be used.

The tennis ball felt is then preferably dyed with a fluorescent dyestuff. That is, the coloured felt will absorb ultra-violet light and re-emit the absorbed energy in the visible area of the spectrum. Most tennis balls are now covered with felt that is dyed fluorescent yellow and which produces peak reflectance values of over 100% in the yellow area of the spectrum.

Few manufacturers produce fluorescent dyestuffs suitable for both wool and polyamide fibres. To the best of the Applicant's knowledge all the major tennis ball felt manufacturers use the same class of dyestuff albeit from different dyestuff suppliers. This class of dyestuff gives a hue (colour) slightly to the green side of yellow.

The cones in the human eye are mainly responsible for daylight colour vision and these give the eye the highest visual efficiency in the yellow wavelengths.

In addition to percentage reflectance three other values can be plotted to identify a colour :

Lightness, with a scale of 0 to 100, 0 being black and 100 white;

Hue, which can be shown as a circle with red at 0 degrees and yellow, green and blue at 90 degree intervals from this, the exact angle therefore indicating the hue. If the lightness is visualised as a vertical axis passing through the centre of the hue circle, then a colour can be plotted in three dimensional space; and

Chroma or colour saturation which can be shown as the distance along a given radius from the centre of the hue circle.

In the mid 1990's a high visibility felt (or HVF) was produced using an increased percentage of dyestuff. This felt (or HVF) has a higher level of saturation (Chroma) but actually has a slight reduction in peak reflectance and in lightness when compared to some standard coloured felt. A method has now been found which allows the production of coloured felt for tennis balls having enhanced visibility properties over the prior art.

The invention also provides a method of dyeing material which produces an Ultra High Visibility

(UHV) felt which mitigates shortfalls of previously available dyed felts.

More particularly, the invention provides a method of colouring fabric material (particularly fabric material which is suitable for use in sports ball manufacture) which method comprises contacting said fabric material with a bleaching agent prior to or simultaneously with contacting said fabric material with a dyestuff providing said colour.

The present invention is based on the fact that the felt used to produce tennis balls typically has a significant wool content (usually 40% or higher). However, the peak reflectance of natural wool fibre in the yellow area of the spectrum is typically around 75% due to the natural yellowish-tinge in even the whitest wool. By means of comparison, titanium dioxide treated nylon would typically have a 90% reflectance. We have found that the naturally low reflectance of wool limits the reflectance achievable even with a fluorescent dye.

The need to bleach a yellowish-fibre (natural wool) prior to or during dyeing that fibre yellow appears counter-intuitive, but we have found that the performance of the dye applied is greatly enhanced by this step.

Preferably the material to be dyed is made of a mixture of fibres of different types, for example, a

mixture of wool and synthetic (eg. polyamide or polyester) fibres. Preferred synthetic fibres are polyamide fibres, for example Nylon 6,6 or Nylon 6. We have found Nylon 6,6 to be most suitable. One or more different synthetic fibres may be present in the fabrics material.

The proportions of wool and synthetic fibres may vary according to the consumer's requirements on cost and performance of the fabric material. For woven fabrics, a wool content of at least 20% (usually 25%) by weight of weft yarn is required.

We have found that better quality fabric material is achieved with increased wool content - for example 30% or higher by weight of weft yarn. Typically a wool content of 40% or above, for example 50% or 60%, by weight of weft yarn achieves good results. For woven fabric, the warp yarn will typically be a cotton yarn, but polyester or polyamide (eg. nylon) could alternatively be used. For non-woven fabrics (eg. needlefelted fabrics) or knitted fabrics a lower wool content (for example in the range of 20-40% by weight, preferably at least 25%) may be sufficient. By "wool" we include wool-like fibres (eg. angora, cashmere and mohair) as well as the more typical sheep's wool.

We have used nylon fibres having a circular cross-section, but synthetic fibres having other cross-sections (eg. triangular or flattened) are

commercially available and may further increase the reflectance achievable.

It is also preferred that the material be a felt and more particularly a felt suitable for the covering of tennis balls. Since a mixture of fibre types (wool and synthetic) are present in the fabric material, it is recommended to contact the fabric material also with a partitioning agent in order to eliminate or reduce the difference in uptake of the dyestuff between the different types of fibres. The bleaching agent, which is preferably a reduction bleaching agent, whitens the initial colour of at least the wool.

Preferably the liquor ratio used to run the machine is in the range between 6:1 and 8:1.

It is further preferred that the pH is adjusted preferably between 4.2 and 4.5 by using, for example, formic acid. The temperature is then raised to a suitable temperature, for example about 45°C and held for a period of, typically, 3 minutes to be able to check and if necessary adjust the pH.

A wide range of suitable partitioning agents are available depending for example upon the nature of the material to be treated. However the partitioning agent sold under the Trade Name BASOPAL NA by BASF has demonstrated good results. The concentration of

BASOPAL NA recommended is about 0.5 grams per litre of liquor.

It is further preferred that the bleaching agent and, if appropriate, the partitioning agent be contacted for a reasonable time with the material prior to the dyeing step being executed.

It is further preferred that the bleaching agent be added simultaneously or quasi-simultaneously with the partitioning agent.

The bleaching agent preferably used is the one sold under the Trade Name LUFIBROL FW by BASF. The amount of LUBRIFOL FW is advantageously about 2% of the weight of fibre.

It is further preferred to use a yellow dye, as this colour is highly desirable for the manufacture of tennis balls. The preferred yellow dye which can be used according to the invention is a dye having a colour index number acid yellow 250 and for example the one sold under the Trade Name NYLOMINE FLAVINE C-7G dyestuff by BASF. The dyeing process can be performed according to the recommended practice. A typical method is to add the dyestuff to the material and the liquor according to a recommended concentration and the recommended temperature is then raised and held for some time at this temperature before rinsing.

The invention also relates to the dyed material obtained according to the method of the invention which is coloured, preferably in yellow, and displays enhanced visibility properties. The invention also relates to the coloured felt itself which displays enhanced visibility properties.

The invention further relates to the used of coloured material dyed according to the method of the invention in the manufacture of articles such as sporting articles and more specifically tennis balls.

The present invention provides a fabric material suitable for use in sports ball manufacture, wherein said material includes at least 20% by weight of wool and exhibits the following characteristics:

a) for a coloured (non-white) fabric material:

   i) a chroma value of 100 or more;
   ii) a lightness value of 95 or more; and
   iii) a reflectance value of 120 or more, or

b) for a white fabric material:

   i) a chroma value of 10 or less;
   ii) a lightness value of 90 or more; and
   iii) a reflectance value of 80 or more.

Desirably, the fabric material includes at least 30% or more, preferably 40% or more, by weight of wool.

It may be desirable to use over 45% by weight of wool and in certain high quality fabric materials 50% by weight of wool, or even 60% by weight of wool (eg. 65% by weight of wool or even up to 70% by weight of wool) may be employed.

For a coloured (non-white) fabric material the chroma value may be higher than 100 (for example 102 or more, preferably 105 or more) and, generally, a high chroma value is desirable provided that the minimum lightness and reflectance values given above for a coloured (non-white) fabric material are maintained. We have achieved a chroma value of over 110, specifically a value of 113.4.

Likewise, for a coloured (non-white) fabric material a lightness value of greater than 95 is desirable (for example of 96 or more, or even 97 or more) provided that the minimum chroma and reflectance values given above for a coloured (non-white) fabric material are also maintained.

Similarly, for a coloured (non-white) fabric material a reflectance value of over 120 (for example 125 or more, preferably 128 or more) is desirable provided that the minimum lightness and chroma values given above for a coloured (non-white) fabric material are also maintained. We have achieved a reflectance value of over 129, specifically a value of 129.9.

In a preferred embodiment, the coloured (non-white) fabric material according to the present invention exhibits the following characteristics:

i) a chroma value of 105 or more (preferably 110 or more);

ii) a lightness value of 96 or more (preferably 97 or more); and

iii) a reflectance value of 125 or more (preferably 128 or more).

For a white fabric material, the chroma value is desirably lower than 10 (for example is 8 or less, preferably is 5 or less) and, generally, a low chroma value (indicating absence of colour) is desirable provided that the minimum lightness and reflectance values given above for a white fabric material are maintained.

Likewise, for a white fabric material a lightness value of greater than 90 is desirable (for example of 92 or more, 93 or more, or 94 or more) provided that the maximum chroma value and minimum reflectance value given above for a white fabric material are maintained.

Similarly, for a white fabric material, a reflectance value of over 80 (for example 85 or more, 90 or more or 95 or more) is desirable provided that the maximum

chroma value and minimum reflectance value given above for a white fabric material are maintained.

In a preferred embodiment, the white fabric material according to the present invention exhibits the following characteristics:

i) a chroma value of 8 or less (preferably 5 or less);

ii) a lightness value of 92 or more (preferably 93 or more); and

iii) a reflectance value of 85 or more (preferably 90 or more).

The present invention further provides a sports ball having a fabric material surface (for example a tennis ball) wherein said sports ball is manufactured using a fabric material as defined above.

In a further aspect, the present invention provides a sports ball having a fabric material outer surface (for example a tennis ball) wherein said fabric material forming said outer surface includes at least 20% by weight of wool and exhibits the following characteristics:

a) for a coloured (non-white) fabric material:

i) a chroma value of 100 or more;

ii) a lightness value of 95 or more; and
iii) a reflectance value of 120 or more, or

b) for a white fabric material:

i) a chroma value of 10 or less;
ii) a lightness value of 90 or more; and
iii) a reflectance value of 80 or more.

Desirably, the fabric material includes at least 30% or more, preferably 40% or more, by weight of wool. It may be desirable to use over 45% by weight of wool and in certain high quality fabric materials 50% by weight of wool, or even 60% by weight of wool (eg. 65% by weight of wool or even up to 70% by weight of wool) may be employed.

For a coloured (non-white) fabric material the chroma value may be higher than 100 (for example 102 or more, preferably 105 or more) and, generally, a high chroma value is desirable provided that the minimum lightness and reflectance values given above for a coloured (non-white) fabric material are maintained. We have achieved a chroma value of over 110, specifically a value of 113.4.

Likewise, for a coloured (non-white) fabric material a lightness value of greater than 95 is desirable (for example of 96 or more, or even 97 or more) provided that the minimum chroma and reflectance

values given above for a coloured (non-white) fabric material are also maintained.

Similarly, for a coloured (non-white) fabric material a reflectance value of over 120 (for example 125 or more, preferably 128 or more) is desirable provided that the minimum lightness and chroma values given above for a coloured (non-white) fabric material are also maintained. We have achieved a reflectance value of over 129, specifically a value of 129.9.

In a preferred embodiment, the coloured (non-white) fabric material according to the present invention exhibits the following characteristics:

i) a chroma value of 105 or more (preferably 110 or more);

ii) a lightness value of 96 or more (preferably 97 or more); and

iii) a reflectance value of 125 or more (preferably 128 or more).

For a white fabric material, the chroma value is desirably lower than 10 (for example is 8 or less, preferably is 5 or less) and, generally, a low chroma value (indicating absence of colour) is desirable provided that the minimum lightness and reflectance values given above for a white fabric material are maintained.

Likewise, for a white fabric material a lightness value of greater than 90 is desirable (for example of 92 or more, 93 or more, or 94 or more) provided that the maximum chroma value and minimum reflectance value given above for a white fabric material are maintained.

Similarly, for a white fabric material, a reflectance value of over 80 (for example 85 or more, 90 or more or 95 or more) is desirable provided that the maximum chroma value and minimum reflectance value given above for a white fabric material are maintained.

In a preferred embodiment, the white fabric material according to the present invention exhibits the following characteristics:

i) a chroma value of 8 or less (preferably 5 or less);

ii) a lightness value of 92 or more (preferably 93 or more); and

iii) a reflectance value of 85 or more (preferably 90 or more).

The invention as described above with reference to coloured (non-white) fabric material (both in respect of the fabric material per se and in respect of the sports ball having a fabric material outer surface) preferably refers to a yellow fabric material.

References to "yellow" refer to any non-white fabric material which is acceptable to the International Tennis Federation (I.T.F.) (since yellow is an accepted coloration of tennis ball according to the I.T.F.). However, this is not exclusive, and other coloured fabric materials (for example pink, green, blue, etc) are also encompassed.

A comparison of the peak reflectance level, chroma, hue and lightness for the fabric according to the invention (U.H.V. F. Yell.) with commercially available alternatives is given in Table 1.

Table 1

Product	Peak Reflectance Level	Chroma (Saturation)	Hue	Lightness
Natural White Tennis Ball Felt	78.46	8.9	92.4	87.8
Milliken Standard F. Yell	122.4	98.2	108.8	96.5
Milliken High Viz. F. Yell.	119.8	112.0	101.3	94.2
U.H.V. F. Yell	129.9	113.4	104.7	97.9
Tretorn TXT Ball	113.1	100.9	104.5	93.6
Pro Penn Ball	124.4	95.8	108.1	95.7

The present invention will be now further described with reference to the following, non-limiting example.

Figure 1 shows the reflectance curves of two prior art felts in ball form (Nos 2 & 3) compared with the ultra high visibility (UHV) felt in fabric form (No 1) of the invention.

Figure 2 shows the reflectance curves of two other felts (Nos 4 & 5) produced by the Applicant and compared with the UHV felt (No 1) of the invention, all in fabric form.

Figure 3 shows the same data as Figure 2 but the data used to produce the curves are generated by the International Tennis Federation on their spectrophotometer.

Figure 4 shows the saturation (chroma) of the UHV felt (No 1) of the invention compared with the four prior art felts (Nos 2 to 5) used in Figures 1 to 3.

Figure 5 shows the lightness of the same five felts used in Figure 4.

Figure 6 is an attempt to illustrate the position on the colour circle by both chroma and hue of the five samples used in Figures 1 to 3, 4 or 5.

Example 1

Production of an ultra high visibility yellow felt according to the method of the invention

The felt used in this example is a fabric material having an back surface made mainly in cotton and a face side made of a wool and polyamide fibre felt (the face side of the fabric forms the external face of the ball). Only the face surface made of wool and polyamide felt needs to be coloured. Wool and polyamide are present in the weft in a ratio of about 60:40 with respect to the weight of wool and polyamide fibres. The amount of cotton fibres in the material represents about 15 % of the total weight of the fabric material.

The felt is dyed using acid dyes in piece form using a Softflow jet dyeing machine which is run at a liquor ratio of between 6:1 and 8:1. The liquor is the liquid in which the material is wetted before the addition of the dyestuff. In most cases and in particular in this example the liquor is water.

The dyeing method used in this example is as follows:-

- The felt is entered into the machine cold and the liquor ratio as indicated above;
- The pH is adjusted between 4.2 and 4.5 with formic acid;
- The temperature is raised to 45°C and held for 3 minutes whilst checking pH;

- 0.5 grams per litre of BASOPAL NA (BASF) and 2% by weight of fibre of Lufibrol FW (BASF) are added through the dosing system; and
- the machine is run for 5 minutes at 45°C.

The following dyeing method is then applied:

- 1.6% by weight of fibres of NYLOMINE FLAVINE C-7G dyestuff is added through the dosing system during a period of 2 minutes;
- the temperature is raised at a rate of 1.8°C per minute to 95°C and the machine is run for 30 minutes at this temperature;
- the temperature is decreased to 40°C at a rate of 2.5°C per minute; and
- the felt is rinsed twice with fresh water and unloaded from the machine.

Comparative data

The colour characteristics of the felt dyed according to the above described method are shown in Figures 1 to 6. Except for Figure 3, all data were measured by the Applicant using CIE (Commission Internationale d'Eclairage) CIELAB formula at a 10 degree reflectance angle using standard D65 illuminant.

Figure 1 shows reflectance curves of an UHV yellow felt made according the method described in Example 1 and of two competing felts in the form of tennis balls produced respectively for the companies Tretorn Sport and Penn Racquet Sports under the Trade Names TRETORN TXT and PRO PENN. The felts used to cover

these balls are produced by Textech Industries. We have found little difference in the spectrophotometric measurements made between a fabric in sheet form and the same fabric when in the form of completed tennis balls.

Figure 2 shows reflectance curves of the UHV felt used in Figure 1 and of two other yellow felts, a "standard" one and an "high visibility" one, both produced by the company Milliken (Woollen Speciality Products) under the respective Trade Names PLAYNE'S 14 and PLAYNE'S 45. These felts are used in the manufacture of tennis balls such as the ones sold under the Trade Names DUNLOP FORT (standard) and SLAZENGER WIMBLEDON (high visibility).

Figure 3 shows the same data as Figure 2 but the data used to produce the curves are generated by the International Tennis Federation (ITF) on their spectrophotometer. This independent measurement shows good correlation with the Applicant's own data.

Figures 4 and 5 show respectively the chroma and the lightness of the five tested felts.

Figure 6 shows a graph displaying the combination of both chroma and hue performances of the five tested felts.

As can be seen from Figures 1 to 6, the colour of the felt of this example of the invention demonstrates

superior characteristics in all areas (i.e. chroma, hue lightness and reflectance). The performances, when compared to the closest prior art (i.e. the High Visibility felt manufacture by Milliken), are especially better for lightness and reflectance.

Figures 2 to 4 & 5 show that the high visibility felt has a higher level of saturation (Chroma) but actually has a slight reduction in peak reflectance and in lightness when compared to the standard colour felt. This disadvantage does not exist with the colour of the UHV felt.

Thus, the UHV felt of the this example of the invention can be used for the manufacture of yellow tennis balls of improved colour properties, which is obviously highly desirable to tennis players. Such improved properties permit, during a game, a more easy and rapid catch (visualisation) of the incoming moving ball by the tennis player and thus a quicker reaction and positioning of the player with respect the ball.

The method and the product thus produced according to the invention may be used for other purposes than covering tennis balls. The high visibility of colour material of the invention could also be used for producing other items than tennis balls, especially those where high visibility is important (for example footballs - especially for indoor use - basketballs and volleyballs).

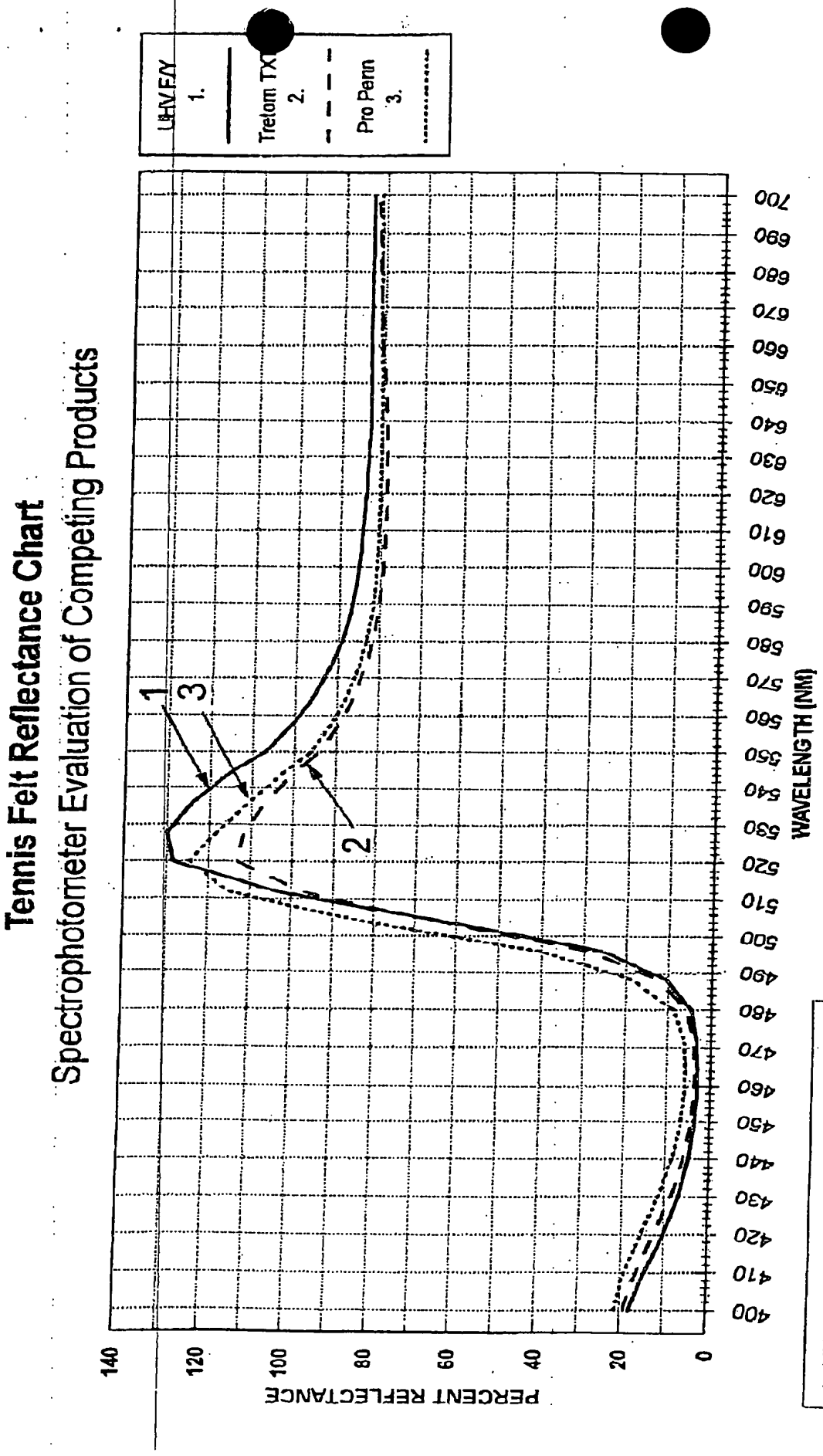
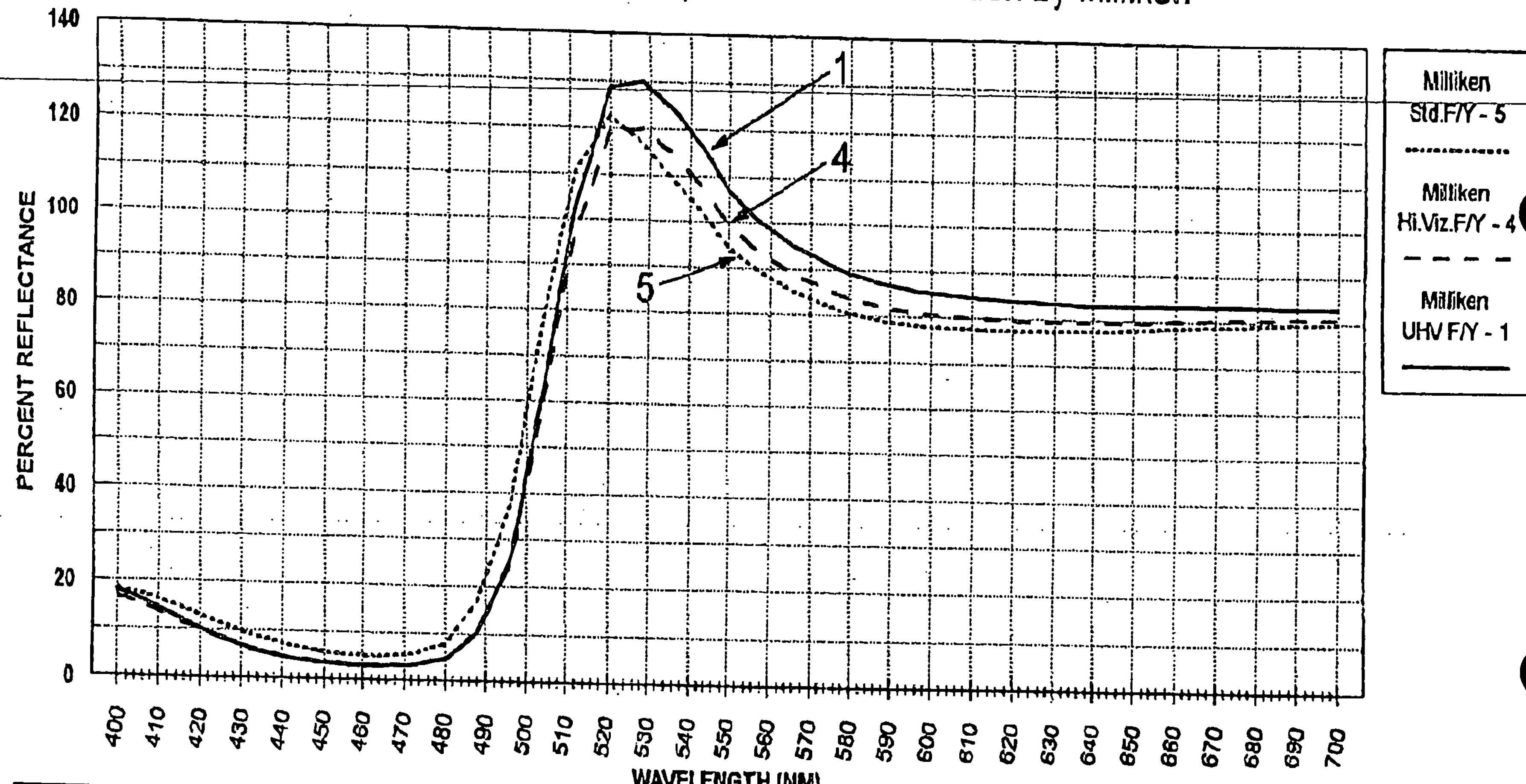

Tennis Felt Reflectance Chart
Spectrophotometer Evaluation of Competing Products
UHV F/Y
1.
Trelom TX
2.
Pro Penn
3.
1
2
3
PERCENT REFLECTANCE
0
20
40
60
80
100
120
140
WAVELENGTH (NM)
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
570
580
590
600
610
620
630
640
650
660
670
680
690
700
1 - UHV F/Y New Milliken development colour
2 - Trelom TXT - Trelom TXT ball from market
3 - Pro Penn - Pro Penn ball from market

FIGURE 1

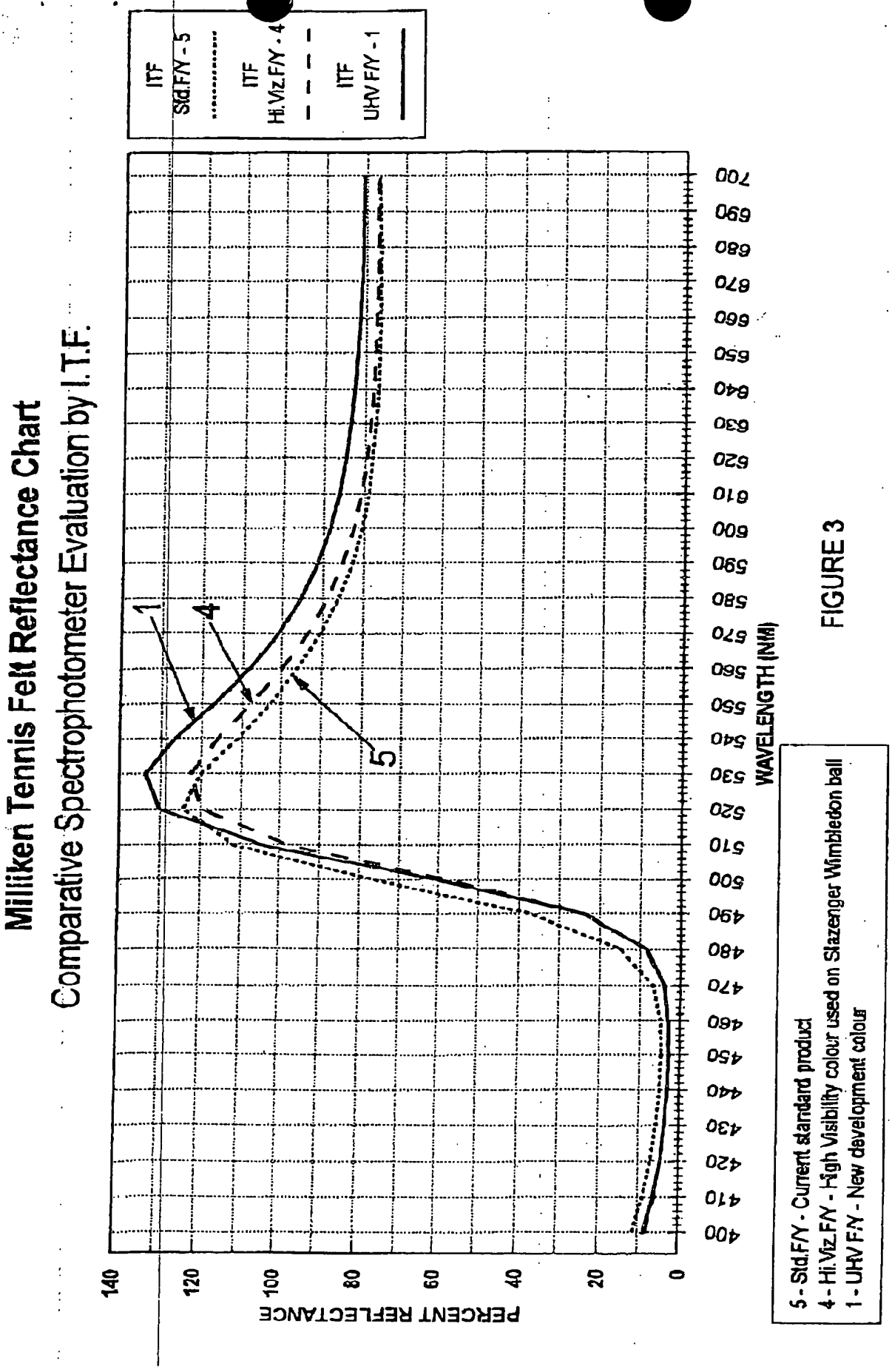
Milliken Tennis Felt Reflectance Chart

Comparative Spectrophotometer Evaluation by Milliken



5 - Std.F/Y - Current standard product
4 - Hi.Viz.F/Y - High Visibility colour used on Slazenger Wimbledon ball
1 - UHV F/Y - New development colour

FIGURE 2


Milliken Tennis Felt Reflectance Chart
Comparative Spectrophotometer Evaluation by I.T.F.
ITF Std.F/Y - 5
ITF Hi.Viz.F/Y - 4
ITF UHV F/Y - 1
1
4
5
PERCENT REFLECTANCE
140
120
100
80
60
40
20
0
WAVELENGTH (NM)
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
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560
570
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610
620
630
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650
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670
680
690
700
5 - Std.F/Y - Current standard product
4 - Hi.Viz.F/Y - High Visibility colour used on Slazenger Wimbledon ball
1 - UHV F/Y - New development colour

FIGURE 3

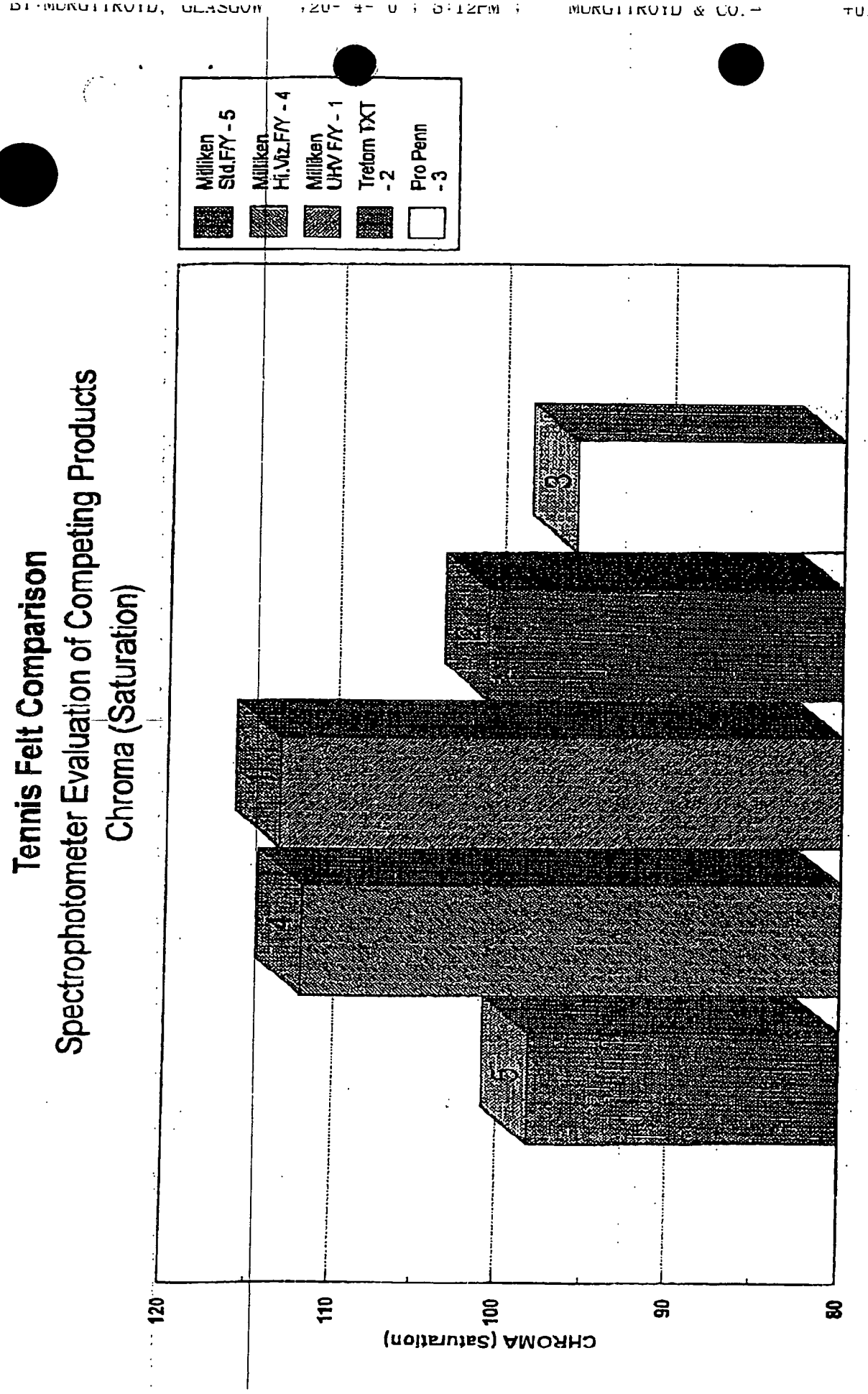
Tennis Felt Comparison
Spectrophotometer Evaluation of Competing Products
Chroma (Saturation)
Milliken Std.F/Y - 5
Milliken Hi.Viz.F/Y - 4
Milliken UHV F/Y - 1
Trelom TXT - 2
Pro Penn - 3
120
110
100
90
80
CHROMA (Saturation)
1
2
3
4
5

FIGURE 4

Tennis Felt Comparison

Spectrophotometer Evaluation of Competing Products

Lightness

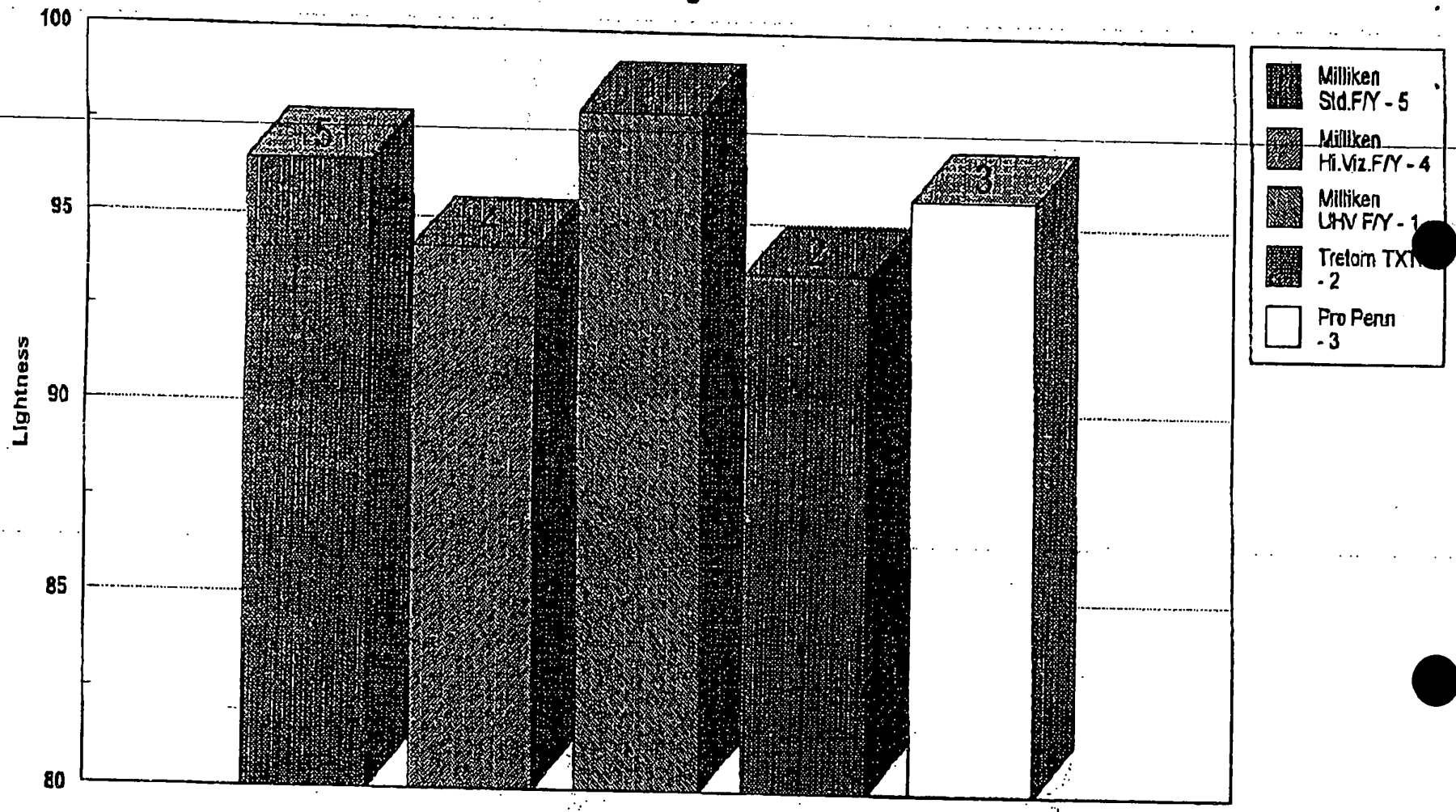

FIGURE 5

PLOT TO SHOW COLOUR COMPARISON OF TENNIS BALL FELT
(CHROMA & HUE)

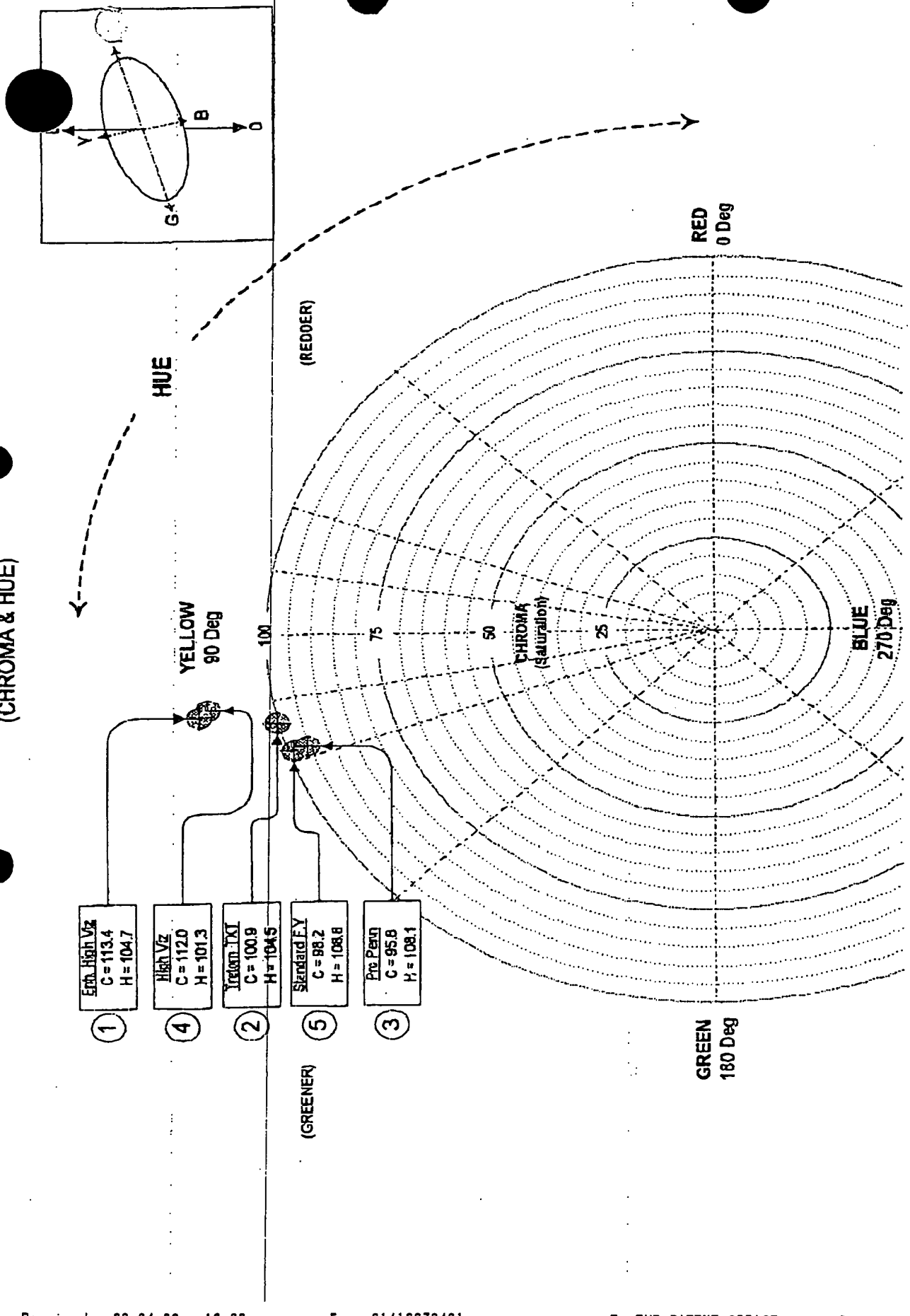

FIGURE 6

PLOT TO SHOW COLOUR COMPARISON OF TENNIS BALL FELT
(CHROMA & HUE)

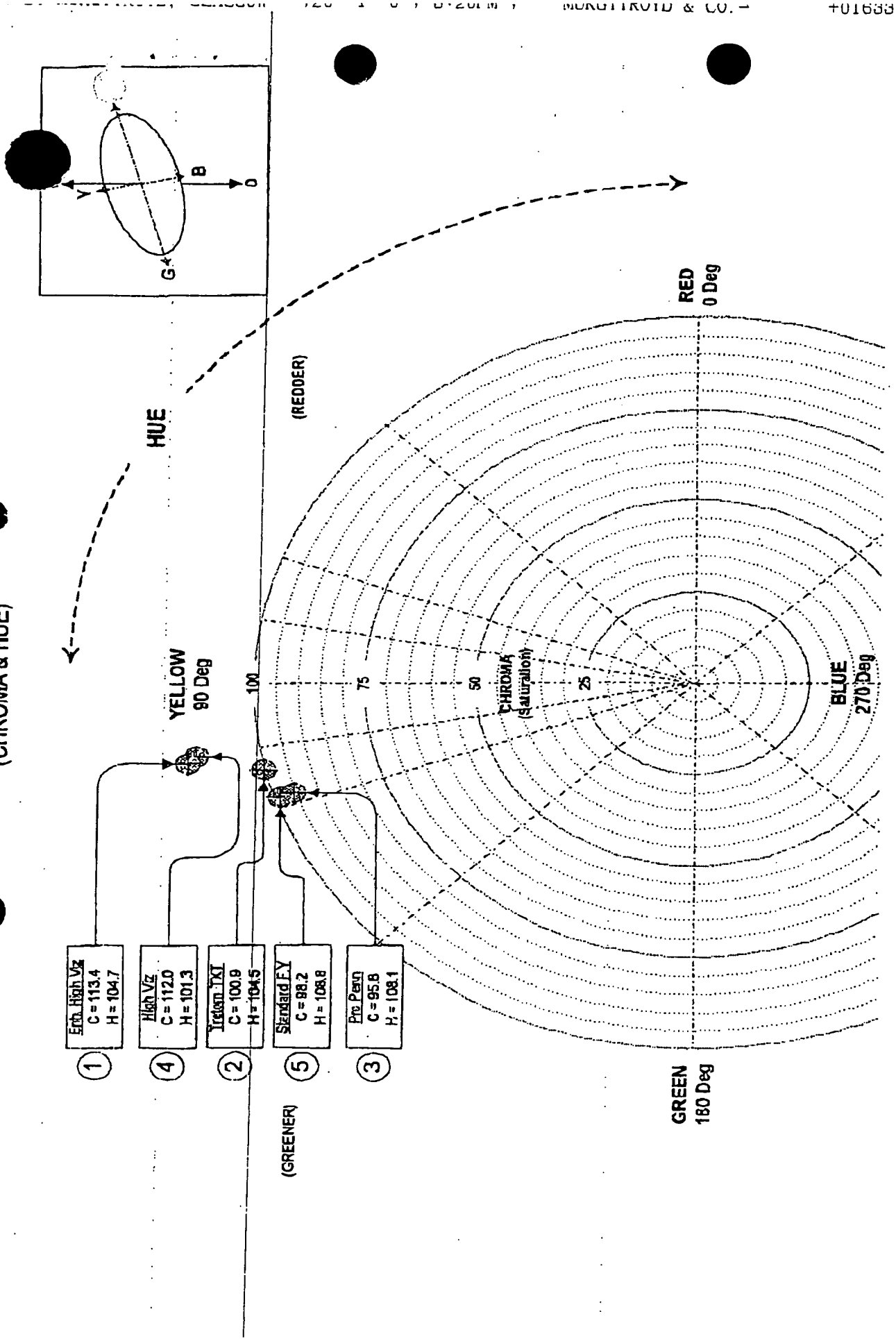

FIGURE 6

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